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United States Patent [19]

Aintablian

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[45] **May 22, 1973**

[54] **USE OF COMPOSTED REFUSE TO MAKE CONSTRUCTION PRODUCTS**

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[21] Appl. No.: **196,767**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 119,564, March 1, 1971, abandoned.

[52] **U.S. Cl.** **264/82,** 71/9, 71/14, 106/90, 106/97, 106/111, 106/119, 106/137

[51] **Int. Cl.** **C04b 31/40,** C04b 15/02, C05f 9/00

[58] **Field of Search**........................264/32, 332, 109; 106/119, 90, 97, 111, 122, 137; 71/14, 8–10

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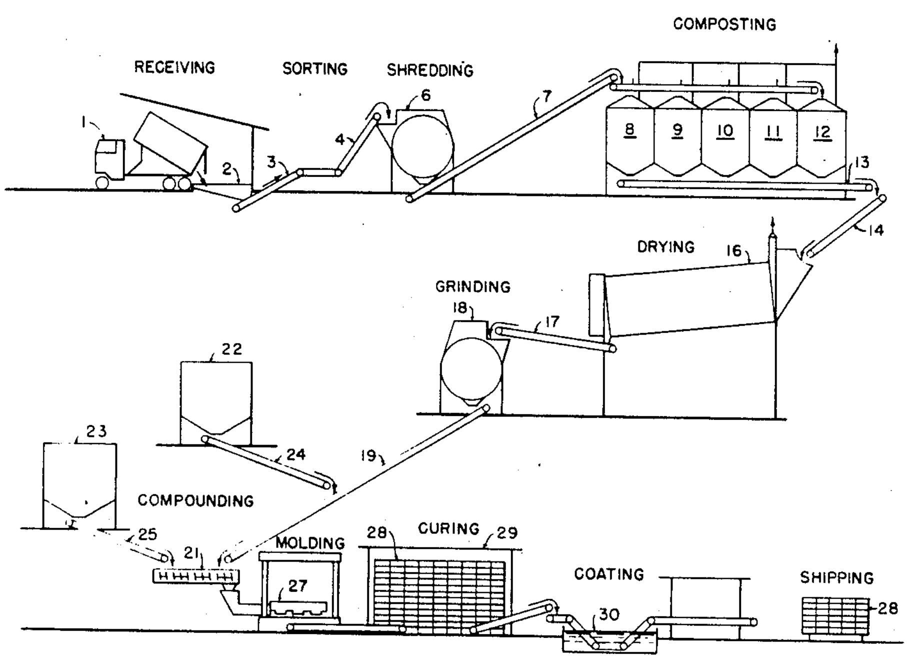
[57] **ABSTRACT**

A process for converting municipal refuse into useable products such as building blocks, wall board, and building bricks which consists of the steps of reducing the size of the refuse to a chip size by shredding; decomposing the refuse in the presence of nitrogen, water and air; drying the chemically processed material in a gas fired dryer to render it biologically inert; grinding the dried material to a fine powder; mixing the powder with fillers and binders such as hydraulic setting cements and glues; adding water and other chemicals as required; forming the blocks or other building materials by pressing; and curing the product until a specified strength has been achieved.

13 Claims, 2 Drawing Figures



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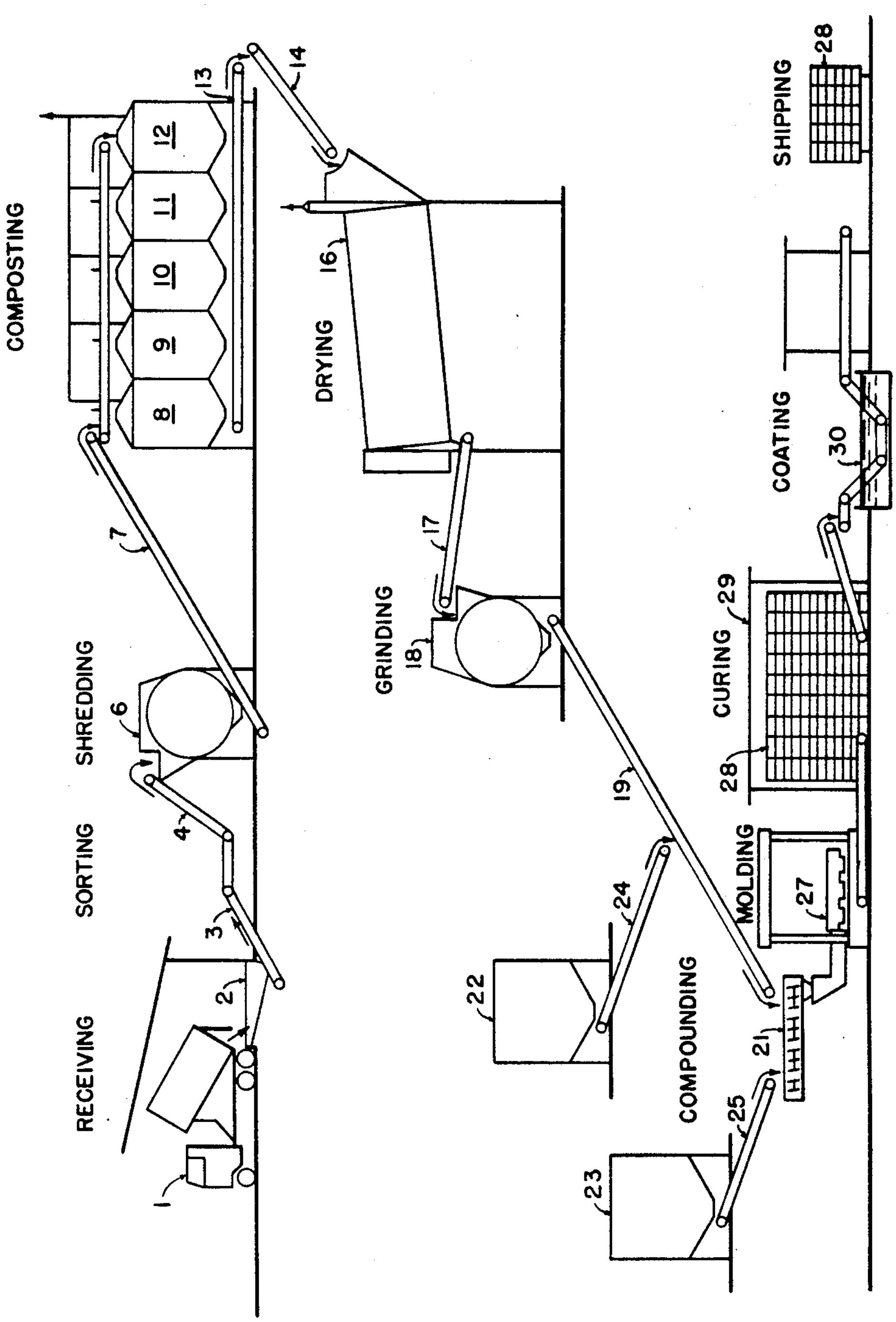

FIG. 1

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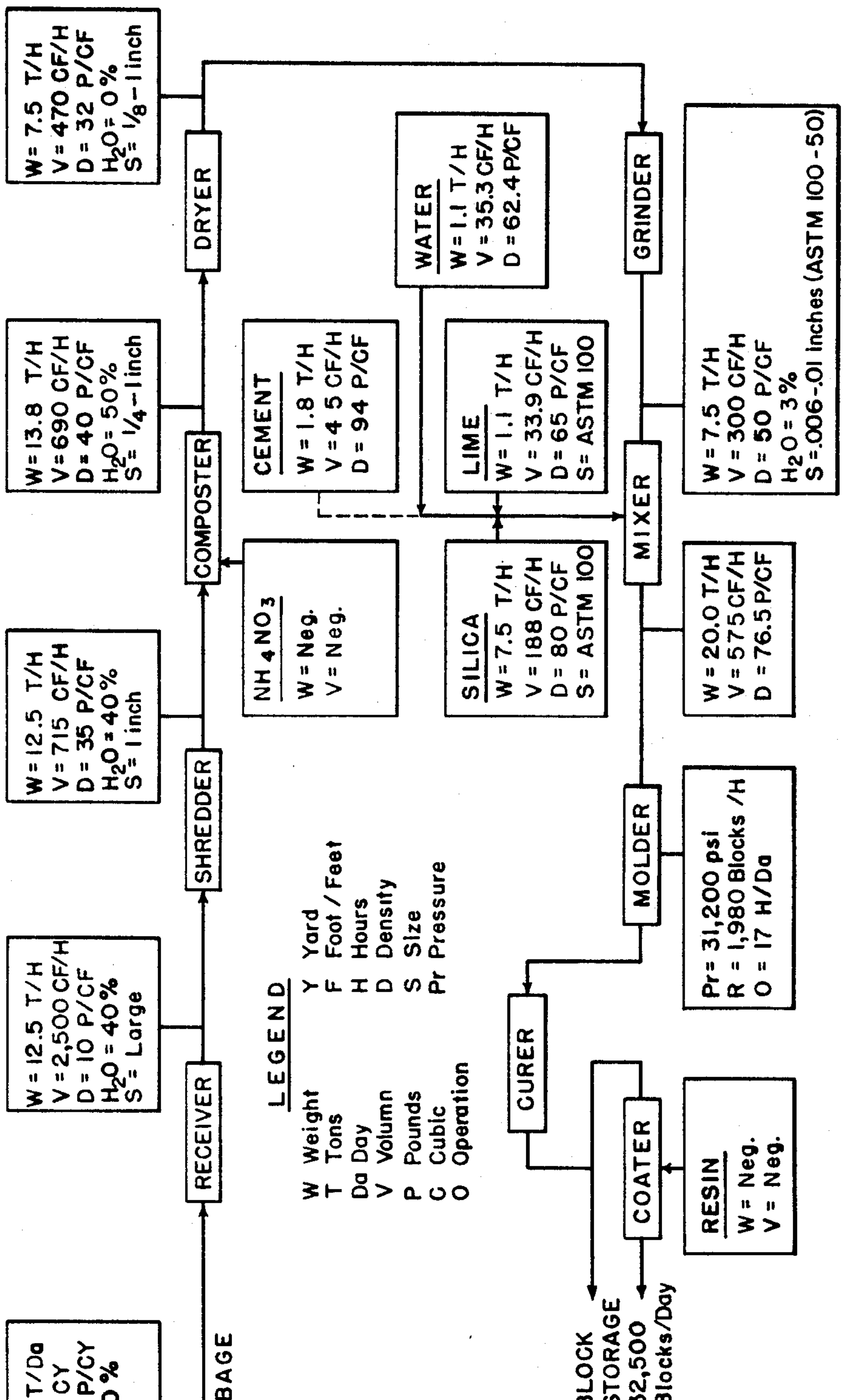

FIG. 2

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USE OF COMPOSTED REFUSE TO MAKE CONSTRUCTION PRODUCTS

The present application is a continuation in part of my prior co-pending U.S. Pat. application Ser. No. 119,564 filed Mar. 1, 1971 and now abandoned.

BACKGROUND OF THE INVENTION

Disposal of urban refuse is a critical, nationwide problem and extensive analysis and research are underway to find viable solutions. The time-honored solution to refuse disposal, atmospheric burning, has ceased in all metropolitan areas. Open burning has usually been replaced with earth burial using cut and fill techniques. Nationally, this is a temporary solution since the large quantities of refuse produced in urban areas are rapidly consuming available sites. Incineration has been tried, but is is expensive and contributes significantly to air pollution. Many costal cities dump refuse at sea but this method must soon cease since there is evidence that refuse contaminants are poisoning the local marine life.

There have been numerous attempts to economically produce building blocks from refuse. One process creates bricks out of the ashes of incinerated refuse. Incineration, however, as previously stated, adds greatly to the particle and thermal pollution of the air.

A Japanese process compacts refuse into blocks and coats them with tar. Thus far the Japanese blocks are unstable and cannot be used in building and have been found unsatisfactory in roads.

BRIEF SUMMARY OF THE INVENTION

The gist of the present invention is a process for quickly converting municipal refuse into useful products which can be used to construct buildings. Accordingly, an object of the present invention is to provide a technically feasible and cost effective process for converting typical municipal refuse in urban areas into a dense, hard stable, odor-free material which can be produced in many forms such as cylinders, blocks having physical characteristics similar to commercial cement blocks and sheets for a variety of building paving and decorating applications.

Another object is to stop the microbiology and chemical reactions quickly so as to effect decomposition in a matter of days instead of the usual several months.

A further object is to produce inert, sterile building construction materials from refuse in an essentially continuous process, and which will retain its construction characteristics and integrity over a long period of time.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic drawing of the equipment used in the process of the present invention.

FIG. **2** is a flow diagram of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

Receiving

Municipal refuse is delivered by trucks **1** or other means and dumped into a receiver **2.** The receiver holds the refuse from approximately two normal size (36 cubic yard) collection trucks. The largest piece size is an object that will fit in a residential garbage can or an approximate maximum of 1 ½ feet. Incoming refuse is approximately 74 cubic yards with a density of approximately 270 pounds per cubic yard. Thus the receiver holds about 10 tons of refuse which is about 40 percent by weight water. Refuse larger than 12 × 12 inches is screened mechanically by a screen graded belt **3** and the smaller classified refuse falls into a receiving hopper and is conveyed to a magnetic separator. The hopper facilitates fly, rodent and odor control. The larger pieces of refuse are sorted for metal or other reuseable product recovery.

Magnetic Separator

Refuse is conveyed to a magnetic drum or a magnetic belt where ferrous metals are extracted and conveyed to a metal bin for salvaging. Iron separation may also be accomplished with a cross belt pickup.

Shredder

The refuse remaining after the preceding separations is then conveyed by belts **4** to a shredder which may be of conventional design. The shredder reduces all items to about 1 × 1 inch size chips. The density of the refuse increases approximately 3.5 times and gives a discharge volume of slightly over 70 cubic feet per hour.

Chemical Processing

The waste is then delivered by conveyers **7** to deconditioning or composting tanks, **8,9, 10,11** and **12** for accelerated biological decomposition. Three days to a week is required for decomposition. Consequently five or more tanks are needed.

Refuse delivered to the deconditioning tank is a mixture of wet material chemically and bacteriologically active. Basically, de-conditioning is a biological process. The environmental factors influence the activities of the organisms in determining the speed and the course of the decomposition cycle. The important factors are: particle size, moisture content, aeration, hydrogen ion concentration, temperature and initial carbon-nitrogen ratio.

To accelerate the decomposition, the following steps are involved:

1. Turning the material at least once a day. The turning process will provide aeration (oxygenation.)
2. Maintaining a moisture content between 40–70 percent. Water is sprayed periodically on the material to maintain this moisture range.
3. Warm air is supplied periodically to maintain the temperature of the material between 50° C. to 80° C.
4. Nitrogen is added periodically. The amount of nitrogen to be added depends upon the carbon content of the material. The ratio of carbon content (C) to nitrogen content (N) to be added is C/N between 20 to 50 percent by weight.
5. When the material has a pH of 6 or less, calcium carbonate or other base acid is added periodically to raise the pH slightly.
6. Composting reduces the particle size of most of the material and consequently increases the density to approximately 40 pounds per cubic foot. Moisture content of the material will be approximately 50 percent.

Drying

After the chemical or deconditioning process, the material is moved by conveyers **13** and **14** and dried by a gas fired heater **16** to render it biologically inert to facilitate grinding to a fine powder and to permit uniform compounding of the final product. Between 60 to 95 percent moisture of the composted material is removed in several hours by the gas fired dryer at a temperature of between 130° to 210° F. The dried material is then conveyed by conveyer **17** to the grinder **18.**

Grinder

The dry material is ground to a fine powder form. To achieve the mesh size needed (approximately 80 mesh size) two passes of the grinding process are required. The ground-up material is then conveyed by conveyer **19** to a mixing tank **21.**

Mixing Tank

In the mixing tank **21,** the fine powdered form material is mixed with additives and binders to provide the required physical characteristics. Dry materials are fed from overhead storage tanks **22** and **23** by proportioning feeders **24** and **25** to the mixer. The basic ingredients of the mixture are as follows:

Mixture	Ratio of Mixture (per cent by weight)
1. De-conditioned material	100%
2. Plaster of Paris	0% to 50%
3. Lime	0% to 50%
4. Silica, as in the form of sand	0% to 60%
5. Calcium as in the form of gypsum (selenite, alabaster, satin or spar)	0% to 50%
6. Portland Cement*	0% to 30%
7. Water	25% to 110%

*The meaning for Portland Cement in the specification and claims is a kind of cement that hardens under water, and is basically made by burning a mixture of limestone and clay, shale, blast furnace slag, marl, iron ore and gypsum. Portland cement is readily attainable as the type ordinarily used in making concrete in building construction. Portland Cement for construction is identified by ASTM NO. C-150. Quick setting cements may also be used such as by (1) heating bauxite and limestone and then grinding to a fine powder, (2) tricalcium silicate or (3) oxychloride cements ($3MgO \cdot MgCl_2 \cdot 10H_2O$).

Three main categories of mixtures are listed below:

Example 1

Mixture	Ratio of Mixture (per cent by weight)
1. De-conditioned material	100%
2. Plaster of Paris	20% to 60%
3. Silica (sand)	25% to 80%
4. Water	26% to 110%

Example 2

1. Deconditioned material	100%
2. Plaster of Paris	20% to 60%
3. Portland cement	10% to 30%
4. Water	25% to 110%

Example 3

1. De-conditioned material	100%
2. Plaster of Paris	25% to 50%
3. Portland cement	10% to 30%
4. Lime	25% to 60%
5. Silica (sand) 30% to 80%	
6. Water	25% to 110%

The correct amount of liquid is controlled by the feeder. Operation of the mixer is continuous and retention time within the mixing chamber is variable.

Molding

The mixture which is prepared in the mixing tank is conveyed to a press **27** for molding into block form **20.** The molding pressure will vary between a load of 15,000 pounds to 75,000 pounds. The pressure is held for about 1 minute or longer to insure that the blocks will be stabilized. Higher pressures are required for larger blocks.

Curing

The blocks are stacked in a curing room **29** with high moisture content. Water spray, as overhead fixtures, provides suspended water spray continuously. The blocks are cured between 1 day to 10 days. The blocks are then ready for use and are stacked in the open air in a yard.

Coating

As required, the blocks may be coated with plastic as by dipping in a tank **30** to give them the desired architectural characteristics.

Further examples and testing results

Sample No. 1 Series

Sample 1A

Deconditioned material	300 grams
Plaster of Paris	150 grams
Portland Cement	75 grams
Water	400 grams

Sample 1B same as 1A except water = 350 grams
Sample 1C same as 1A except water = 300 grams
Sample 1D same as 1A except water = 250 grams

Test results of Sample No. 1 Series

Sample	Specimen	Density lbs./ft.	% water by wt.	Molding pressure	Strength psi.
1A	1a	113–00	70%	15,000	1,450
	1b	109–00	70%	10,000	1,125
	1c	102–00	70%	5.00	650
LB	1a	112–00	60%	15.000	1,400
	1b	110–00	"	10.000	1,175
	1c	99–00	"	5,000	655
1C					
	1a	113–00	50%	15,000	1,275
	1b	108–00	"	10.000	900
	1c	100–00	37	5,000	390
1D	1a	110–00	40%	15,000	800
	1b	109–00	"	10,000	680
	1c	103–00	"	5,000	420

Block sixe for the samples in series **1** was 1 ×1 ×4 inches.

Sample No. 2 Series

In a second series of test samples, the same formulation as the sample No. 1 series was used except that 400 grams of water was added and the curing time was increased. The test results showed a dramatic increase in compressive strength as indicated by tests by Twining Laboratories of Southern California, Inc. as follows:

Test results of Sample No. 2 Series (1 ½ diameter cylinders)

Specimen	Load	Compressive Strength
No. 1	3,720 lbs.	2,105 psi.
No. 2	3,260 lbs.	1,845 psi.
No. 3	3,420 lbs.	1,935 psi.
No. 4	3.120 lbs.	1,766 psi.

Sample No. 3 Series

De-conditioned material	45%
Silica (sand)	75%
Plaster of Paris	11.2%
Portland Cement	6.8%
Water	25 to 30%

Test results of Sample No. 3 series

The average compressive failure was 1,400 psi.

Sample No. 4 Series

Specimen	Deconditioned Mixture grams	Plaster of Paris grams	Portland Cement grams	H_2O gr.	Molding Pressure lbs.
A	100	40	20	122	15,000
B	100	40	20	100	20,000
C	100	40	20	60	30.000
D	100	40	20	80	25,000
E	100	40	20	40	35,000
F	100	40	20	122	15,000
G	Deconditioned material		100 grams		
	Silica (sand)		100 grams		
	Lime		10 grams		
	Water		160 grams		

Bacteriological Tests

Tests for bacteriological activity and for pH reading were conducted by the Orange Coast College in Costa Mesa, California and the results are shown below:

	2a	1	2	3	4
Nutrient broth (a complete growth media)	neg	neg	neg	neg	neg
Nutrient agar (a complete growth media)	"	"	"	"	"
EMB agar (indication media for enterics)	"	"	"	"	"
Sodium thioglycolate nutrient semi-solid (indication of anaerobic bacteria)	"	"	"	"	"
Lactose broth with Durham tube (indication of gas production)	"	"	"	"	"
Glucose broth with Durham tube (indication of gas production)	"	"	"	"	"

Above results after 48 hours

pH Tests

All pH tests were performed by dissolving 1 gram of material in 10 milliliters of pH 7.0 buffer. Results are based on the average of three readings.

	2a	1	2	3	4
pH	7.63	7.17	7.13	7.1	7.13

The foregoing test show that blocks having compressive strength of 1,450 psi are obtainable which is in excess of the compressive strength of commercial cement blocks which is between 800 and 1,240 psi. Further the bacteriological tests show that the block is inert and may in fact be more inert than commercial cement block because it is essentially non-porous and therefore bacteria has a difficult time growing in the present block.

In the deconditioning step of the process it has been found that nitrogen may be introduced in the form of ammonium sulfate, $(NH_4)_2SO_4$; nitrogen tri-oxide, N_2O_2; ammonium nitrate, NH_4NO_3; sodium nitrate, $NaNO_3$; or equivalent.

Referring to FIG. 2, a flow diagram is shown for the operation of a plant having a capacity of 100 tons of refuse per day. This refuse has a volume of 740 cubic yards and a water content of 40 percent. The density and water content will of course vary but a typical density is about 270 pounds per cubic yard. Such a plant should have a receiver having a capacity to take 12.5 tons of refuse per hour with a volume of 2,500 cubic feet per hour. Density is about 10 pounds per cubic foot with a water content still at 40 percent and still containing the large pieces.

The product is fed through a standard shredder which has a capacity of 12.5 tons per hour and processes 715 cubic feet per hour. The density is raised by shredding to 35 pounds per cubic foot. The size is reduced to about 1 inch and the water content remains at 40 percent.

In the de-conditioner, nitrogen in the form of ammonium nitrate or the other compounds of nitrate set forth above are added in the amounts above specified. The de-conditioner should have a capacity of about 690 cubic feet per hour with a weight capacity of 13.8 tons per hour. Density again increases to 40 pounds per cubic foot and the water content is raised by the addition of water to 50 percent. Size is now reduced to ¼–1 inch.

In the dryer which has a capacity of 7.5 tons per hour and a volume of 470 pounds per cubic foot the density is increased to 32 pounds per cubic foot and the water content is negligible. Size is further reduced to one-eight inch to 1 inch.

After grinding, the following materials in batch quantities are added. Water, 1.1 tons per hour, 35.3 cubic feet per hour with a density of 62.4 pounds per cubic foot. Lime, 1.1 tons per hour at a volume of 33.9 cubic feet per hour and a density of 65 pounds per cubic foot. Size is ASTM 100. Silica is added at the rate of 7.5 tons per hour at a volume of 188 cubic feet per hour and having a density of 80 pounds per cubic foot and a size of ASTM 100.

For extra strength Portland cement may be added at the rate of 1.8 tons per hour having a volume of 45 cubic feet per hour at 94 pounds per cubic foot.

The de-conditioned product added to the mixer at this point in the process is 7.5 tons per hour with a volume of 300 cubic feet per hour. Density is 50 pounds per cubic foot and water content is 3 per cent. Size is 0.006 to 0.01 inches (ASTM 100 – 50).

The above process makes about 32,500 blocks per day in a molder which subjects each block to 31,200 psi. at a rate of 1,980 blocks per hour working 17 hours per day.

Wall board is made by taking dry de-conditioned material in a ratio of about 75 to 90 percent from the dryer and mixing it with 10 to 25 percent Elmer's Glue or equivalent (such as Resorcinol water proof glue by U.S. Plywood or any marine glue used by companies to make plywood) and pressing between two sheets for forming. The wall board is then dried for about 24 hours. Other glues which may be used are Plyobord Super Glue by Goodyear and two component epoxy glues.

Floor tile is best made using 75 to 90 percent de-conditioned material and 10 to 25 percent Plyobord Super Glue or Elmer's Glue.

It is to be understood that the process described above and the sizes given are exemplary only. By changing the size and proportions of the formulas a plant can handle anywhere from 100 tons a day to a 1,000 tons a day or more.

I claim:

1. A process for converting municipal refuse that is chemically and bacteriologically active to building construction blocks comprising:

a. shredding said refuse and reducing it to approximately 1 inch chip size;

b. de-conditioning said shredded refuse for approximately 3 to 7 days in a de-conditioning tank including the steps of:

1. adding nitrogen in a form selected from the group consisting of ammonium sulfate, nitrogen tri-oxide, ammonium nitrate and sodium nitrate, periodically so that the ratio of carbon content to nitrogen content is between 20 and 50 by weight,
2. adding water so that the moisture content is between 40 and 70 percent,
3. maintaining a temperature between 50° and 80° C.,
4. aerating the deconditioned material as by turning periodically,
5. maintaining a pH of slightly more than 6,

c. drying said de-conditioned material and removing 60 to 90 percent of the water;

d. grinding said dried de-conditioned material to a fine powder form:

e. adding additives and binders selected from the group consisting of plaster of paris, lime, silica, portland cement, calcium in a form selected from the group consisting of gypsum, selenite, alabaster, satin, and spar, and water and mixing;
f. compressing the mixture into a pre-selected mold; and
g. curing the molded product in a moist atmosphere until the desired strength has been achieved.

2. A process as defined in claim 1 comprising:
a. said nitrogen being added in the form of ammonium sulfate.

3. A process as defined in claim 1 comprising:
a. said nitrogen being added in the form of nitrogen tri-oxide.

4. A process as defined in claim 1 comprising:
a. said nitrogen being added in the form of ammonium nitrate.

5. A process as defined in claim 1 comprising:
a. said nitrogen being added in the form of sodium nitrate.

6. A process as defined in claim 1 comprising:
a. said pH being maintained by the addition of calcium carbonate.

7. A process as defined in claim 1 comprising:
a. said binders and additives consisting of plaster of paris and silica.

8. A process as defined in claim 1 comprising:
a. said binders and additives consisting of plaster of paris and portland cement.

9. A process as defined in claim 1 comprising:
a. said binders and additives consisting of plaster of paris, portland cement, lime and silica.

10. A process as defined in claim 1 comprising:
a. said binders and additives consisting of plaster of paris, lime, silica, calcium (in a form selected from the group consisting of gypsum, selenite, alabaster, satin, or spar), and portland cement.

11. A process as defined in claim 1 comprising:
a. said compression step being held for at least about 1 minute.

12. A process for converting municipal refuse that is chemically and bacteriologically active to building wall board comprising the steps of:
a. shredding said refuse and reducing it to approximately 1 inch chip size;
b. de-conditioning said shredded refuse for approximately three to seven days in a deconditioning tank including the steps of:
1. adding nitrogen periodically so that the ratio of carbon content to nitrogen content is between 20 and 50 by weight,
2. adding water so that the moisture content is between 40 and 70 percent,
3. maintaining a temperature between 50° and 80° C.,
4. aerating the de-conditioned material as by turning periodically
5. maintaining a pH of slightly more than 6
c. drying said de-conditioned material and removing 60 to 90 percent of the water;
d. adding a glue binder and mixing; and
e. compressing the mixture of de-conditioned material and glue additive into a sheet; and
f. curing said sheet until the desired strength has been achieved.

13. A process for converting municipal refuse that is chemically and bacteriologically active to building floor tile comprising the steps of:
a. shredding said refuse and reducing it to approximately 1 inch chip size;
b. deconditioning said shreeded refuse for approximately three to 7 days in a deconditioning tank including the steps of:
1. adding nitrogen periodically so that the ratio of carbon content to nitrogen content is between 20 and 50 percent by weight,
2. adding water so that the moisture content is between 40 and 70 percent,
3. maintaining a temperature between 50° and 80° C.,
4. aerating the deconditioned material as by turning periodically,
5. maintaining a pH of slightly more than 6,
c. drying said deconditioned material and removing 60 to 90 percent of the water;
d. adding 10 to 25 percent by weight of a glue binder and mixing; and
e. compressing the mixture of deconditioned material and glue additive into a sheet; and
f. curing said sheet until the desired strength has been achieved.

* * * * *